2021 - 2022, HS, Physics, Quarter 1

Big Ideas/Key Concepts:

- **Changes in the position of an object over time can be modelled in a variety of ways.**
- **Motion in the x-direction is independent of motion in y-direction.**
- **Laws of mechanics are the foundations of classical physics.**
- **Forces and interactions between objects are used to describe an object's motion and to determine the stability in a system.**

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Standards	Student Friendly "I Can" Statements
One Dimensional Motion	**One Dimensional Motion**
PHYS.PS2.1 Investigate and evaluate the graphical and mathematical relationship (using either manual graphing or computers) of one-dimensional kinematic parameters (distance, displacement, speed, velocity, acceleration) with respect to an object's position, direction of motion, and time.	I can categorize quantities as a scalar or vector quantity. I can create motion graphs from laboratory data. I can create and interpret motion graphs for a given scenario. I can model the relationships between displacement, velocity, and acceleration using equations.
PHYS.PS2.2 Algebraically solve problems involving constant velocity and constant acceleration in one-dimension.	I can solve problems using $v=\Delta d/\Delta t$, $a=\Delta v/\Delta t$, $d=1/2at^2+vt+d_0$. I can identify relevant information in a given scenario to solve motion problems.
Two Dimensional Motion	**Two Dimensional Motion**

PHYS.PS2.13 Develop a model to predict the range of a two-dimensional projectile based upon its starting height, initial velocity, and angle at which it was launched.	I can add or subtract vectors graphically and by components. I can solve projectile motion problems. I can develop a model that calculates the range of a projectile.
<u>Newton's Laws of Motion</u>	**<u>Newton's Laws of Motion</u>**
PHYS.PS2.4 Use free-body diagrams to illustrate the contact and non-contact forces acting on an object. Use the diagrams in combination with graphical or component-based vector analysis and with Newton's first and second laws to predict the position of the object on which the forces act in a constant net force scenario.	I can create and interpret free-body diagrams (FBDs). I can calculate the net force acting on an object. I can predict the position of an object experiencing no net force.
PHYS.PS2.5 Gather evidence to defend the claim of Newton's first law of motion by explaining the effect that balanced forces have upon objects that are stationary or are moving at constant velocity.	I can gather evidence and prove Newton's first law. I can solve problems using F_{net} = ma.
PHYS.PS2.7 Plan, conduct, and analyze the results of a controlled investigation to explore the validity of Newton's second law of motion in a system subject to a net unbalanced force, $F_{net} = ma$ or $F_{net} = \Delta p/\Delta t$.	I can plan, conduct, and analyze an experiment that demonstrates Newton's second law. I can use experimental evidence to prove the velocity dependence of air resistance.
PHYS.PS2.12 Use experimental evidence to demonstrate that air resistance is a velocity dependent drag force that leads to terminal velocity.	I can explain the phenomenon of terminal velocity. I can give and explain examples of Newton's third law.

PHYS.PS2.8 Use examples of forces between pairs of objects involving gravitation, electrostatic, friction, and normal forces to explain Newton's third law.	

2021 - 2022, HS, Physics, Quarter 2

Big Ideas/Key Concepts:

- **Forces and interactions between objects are used to describe an object's motion and to determine the stability in a system.**
- **Properties of matter (mass, charge, and spin) give rise to fields and forces.**
- **Energy flows in and out of a system in a predictable way.**

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Standards	Student Friendly "I Can" Statements
Gravitation and Circular Motion	**Gravitation and Circular Motion**
PHYS.PS2.3 Algebraically solve problems involving arc length, angular velocity, and angular acceleration. Relate quantities to tangential magnitudes of translational motion.	I can solve problems involving arc length, angular velocity, and angular acceleration. I can convert between angular velocity and tangential velocity.
PHYS.PS2.9 Use Newton's law of universal gravitation, F = Gm1m2/r2, to calculate the gravitational forces, mass, or distance separating two objects with mass, given the information about the other quantities.	I can solve problems using Newton's law of universal gravitation, $F=Gm_1m_2/r^2$. I can explain how gravity can act at a distance. I can explain how massive objects generate and interact with gravitational fields
PHYS.PS2.14 Plan and conduct an investigation to provide evidence that a constant force perpendicular to an object's motion is required for uniform circular motion (F = m v2 / r).	I can plan and carry out an investigation of the relationship between a centripetal force and an object's circular motion.

<u>Work and Energy</u> **PHYS.PS3.1** Identify and calculate different types of energy and their transformations (thermal, kinetic, potential, including magnetic and electrical potential energies) from one form to another in a system. **PHYS.PS3.3** Use the principle of energy conservation and mathematical representations to quantify the change in energy of one component of a system when the energy that flows in and out of the system and the change in energy of the other components is known. **PHYS.PS3.8** Communicate scientific ideas to describe how forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space. Explain how energy is contained within the field and how the energy changes when the objects generating and interacting with the field change their relative positions. **PHYS.PS3.6** Define power and solve problems involving the rate of energy production or consumption ($P = \Delta E/\Delta t$). (Exclude electrical systems. This standard is revisited in quarter 4). **<u>Momentum</u>** **PHYS.PS3.4** Assess the validity of the law of conservation of linear momentum (p=mv) by planning and constructing a controlled scientific investigation involving two objects moving in one-dimension.	**<u>Work and Energy</u>** I can define and calculate the work being done on an object. I can apply the work-energy theorem to solve problems. I can calculate kinetic energy and gravitational potential energy. I can identify transformations between gravitational and kinetic energy. I can solve problems involving potential, kinetic, and total energy. I can describe how a massive object gains or loses energy as it moves in a gravitational field. I can define power and solve problems using $P = \Delta E/\Delta t$. **<u>Momentum</u>** I can design and carry out an experiment that tests the law of conservation of momentum (p=mv). I can cite experimental evidence to assess the validity of the law of conservation of momentum.

PHYS.PS2.6 Using experimental evidence and investigations, determine that Newton's second law of motion defines force as a change in momentum, $F = \Delta p/\Delta t$. **PHYS.PS2.11** Develop and apply the impulse-momentum theorem along with scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on an object during a collision (e.g. helmet, seatbelt, parachute).	I can use evidence to determine the relationship between the net force on an object and its change in a momentum. I can apply the impulse-momentum theorem to design a device to minimize the force on an object in a collision. I can evaluate the performance of the device and refine the design through the use of data analysis and modelling.

2021 - 2022, HS, Physics, Quarter 3

Big Ideas/Key Concepts:

- **Waves carry energy without transporting matter.**
- **Wave behavior is medium dependent.**
- **Electromagnetic waves are used to transmit information.**
- **Photons behave as both particles and waves.**

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Standards	Student Friendly "I Can" Statements
Waves	**Waves**
PHYS.PS4.1 Know wave parameters (i.e., velocity, period, amplitude, frequency, angular frequency) as well as how these quantities are defined in the cases of longitudinal and transverse waves.	I can compare and contrast longitudinal and transverse waves. I can describe the velocity, period, amplitude, frequency, and angular frequency of a wave.
PHYS.PS4.2 Describe parameters of a medium that affect the propagation of a sound wave through it.	I can describe factors that affect the behavior of a sound wave. I can give examples of conditions that affect the speed of sound in air.
PHYS.PS4.3 Understand that the reflection, refraction, and transmission of waves at an interface between two media can be modeled on the basis of characteristics of specific wave parameters and parameters of the medium.	I can model and qualitatively predict how wave will reflect or refract at the boundary of two media.

PHYS.PS4.4 Communicate scientific and technical information about how the principle of superposition explains the resonance and harmonic phenomena in air columns and on strings and common sound devices.	I can explain the phenomenon of standing waves using the superposition principle. I can identify the parts of a standing wave. I can model and explain the phenomenon of resonance in common sound devices.
<u>Optics</u>	**<u>Optics</u>**
PHYS.PS4.6 Plan and conduct controlled scientific investigations to construct explanations of light's behavior (reflection, refraction, transmission, interference) including the use of ray diagrams.	I can create and interpret ray diagrams. I can design and carry-out investigations to derive patterns of reflection, refraction, transmission, and interference. I can calculate the distance to the image for a given mirror or lens scenario given the distance to the object and focal length.
PHYS.PS4.9 Investigate how information is carried in optical systems and use Snell's law to describe the properties of optical fibers.	I can describe the image (real or virtual, upright or inverted). I can investigate how optical fibers carry information.
<u>The Electromagnetic Spectrum</u>	**<u>The Electromagnetic Spectrum</u>**
PHYS.PS4.5 Evaluate the characteristics of the electromagnetic spectrum by communicating the similarities and differences among the different bands. Research and determine methods and devices used to measure these characteristics.	I can articulate the similarities and differences among the different bands of the electromagnetic spectrum. I can research how characteristics of electromagnetic waves are measured.
PHYS.PS4.7 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model.	I can cite specific historical experiments to defend a wave model or particle model of light. I can explain the reasoning behind the idea of wave/particle duality of light.

PHYS.PS4.8 Obtain information to construct explanations on how waves are used to produce, transmit, and capture signals and store and interpret information.	I can research and explain how waves are used in communications.

2021 - 2022, HS, Physics, Quarter 4

Big Ideas/Key Concepts:

- **Only a few properties of matter (charge, mass, spin) produce all the forces and fields we experience.**
- **Electric circuits control the flow of electrons to convert electrical energy into other useful forms of energy.**
- **The laws of thermodynamics govern the flow of energy in and out of a system.**
- **Nuclear reactions are the consequence of competing electrical and nuclear forces.**

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Standards	Student Friendly "I Can" Statements
Electric Force and Magnetism	**Electric Force and Magnetism**
PHYS.PS2.10 Describe and mathematically determine the electrostatic interaction between electrically charged particles using Coulomb's law, Fe = ke = q1q2/r2. Compare and contrast Coulomb's law and gravitational force, notably with respect to distance.	I can solve problems using Coulomb's law: Fe=kq1q2/r2 . I can compare and contrast electric and gravitational forces
PHYS.PS3.8 Communicate scientific ideas to describe how forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space. Explain how energy is contained within the field and how the energy changes when the objects generating and interacting with the field change their relative positions. **(This standard was also addressed in quarter 2)**	I can explain how electric forces can act at a distance. I can explain how charged objects generate and interact with electric fields. I can describe how a charge gains or loses energy as it moves in an electric field.
PHYS.PS3.9 Describe, compare, and diagrammatically represent both electric and magnetic fields. Qualitatively predict the motion of a	I can draw and interpret diagrams of electric and magnetic fields.

charged particle in each type of field, but avoid situations where the two types of fields are combined in the same region of space. Restrict magnetic fields to those that are parallel or perpendicular to the path of a charged particle.	I can explain how charged objects generate and interact with magnetic fields. I can compare the motion of a charged particle in an electric field versus a magnetic field.
PHYS.PS3.1 Identify and calculate different types of energy and their transformations (thermal, kinetic, potential, including magnetic and electrical potential energies) from one form to another in a system. **(This standard was also addressed in Quarter 2.)**	I can identify and calculate electrical potential energy.
<u>Electricity and Circuits</u>	**<u>Electricity and Circuits</u>**
PHYS.PS3.10 Develop a model (sketch, CAD drawing, etc.) of a resistor circuit or capacitor circuit and use it to illustrate the behavior of electrons, electrical charge, and energy transfer.	I can draw and interpret circuit diagrams. I can describe the energy flow and behavior of electrons in an electric circuit.
PHYS.PS3.11 Investigate Ohm's law (I=V/R) by conducting an experiment to determine the relationships between current and voltage, current and resistance, and voltage and resistance.	I can design and carry-out an experiment that determines the relationship between current, voltage, and resistance. I can solve problems using Ohm's law (I=V/R).
PHYS.PS3.12 Apply the law of conservation of energy and charge to assess the validity of Kirchhoff's loop and junction rules when algebraically solving problems involving multi-loop circuits.	I can apply the law of conservation of energy to electric circuits. I can find the equivalent resistance for series, parallel, and combination circuits.
PHYS.PS3.13 Predict the energy stored by a capacitor and how charge flows among capacitors connected in series or parallel.	I can predict how charge flows among capacitors. I can solve for the energy stored by a capacitor

PHYS.PS3.6 Define power and solve problems involving the rate of energy production or consumption ($P = \Delta E/\Delta t$). Explain and predict changes in power consumption based on changes in energy demand or elapsed time. Investigate power consumption and power production systems in common use. **(This standard was also addressed in Quarter 2.)** **PHYS.PS3.15** Compare and contrast the process, design, and performance of numerous next-generation energy sources (hydropower, wind power, solar power, geothermal power, biomass power, etc.). **PHYS.PS3.14** Recognize and communicate information about energy efficiency and/or inefficiency of machines used in everyday life. **<u>Thermodynamics</u>** **PHYS.PS3.2** Investigate conduction, convection, and radiation as a mechanism for the transfer of thermal energy. **PHYS.PS3.5** Construct an argument based on qualitative and quantitative evidence that relates the change in temperature of a substance to its mass and heat energy added or removed from a system.	I can solve problems involving the rate of energy production or consumption ($P = \Delta E/\Delta t$). I can explain and predict changes in power consumption as energy demand changes. I can research the current state of the electric grid and evaluate proposed improvements to it. I can defend and critique the benefits and risks of different energy sources. I can explain efficiency in terms of energy loss, energy transformations, and work. I can communicate information about the efficiency of everyday machines. **<u>Thermodynamics</u>** I can investigate the types of thermal energy transfer. I can explain conduction, convection, and radiation using particle and wave models. I can use evidence to relate change in temperature, mass, and heat energy. I can solve specific heat problems using $Q = cm\Delta T$. I can model heat flow between hot and cold objects.

PHYS.PS3.7 Investigate and evaluate the laws of thermodynamics and use them to describe internal energy, heat, and work.	I can relate internal energy, heat, and work. I can describe examples of the laws of thermodynamics in a variety of scenarios.
<u>**Nuclear Physics**</u>	<u>**Nuclear Physics**</u>
PHYS.PS1.1 Develop models to illustrate the changes in the composition of the nucleus of an atom and the energy released during the processes of fission, fusion, and radioactive decay.	I can model and describe the parts of an atom. I can construct models that illustrate the processes of fission, fusion, and radioactive decay.
PHYS.PS1.2 Recognize and communicate examples from everyday life that use radioactive decay processes.	I can recognize and communicate everyday examples of nuclear decay.
PHYS.PS1.3 Investigate and evaluate the expression for calculating the percentage of a remaining atom (N(t)=N0e-λt) using simulated models, calculations, and/or graphical representations. Define the half-life (t1/2) and decay constant λ. Perform an investigation on probability and calculate half-life from acquired data (does not require use of actual radioactive samples).	I can solve problems using $N(t)=N_0e^{-\lambda t}$. I can define and relate half-life and the decay constant (λ). I can calculate the amount of a radioactive material that remains in a given scenario using models such as simulations, calculations, and graphs.